Department for Work and Pensions

Department for Work and Pensions Social Security Administration Act 1992

Osteoarthritis of the knee in carpet fitters and carpet and floor layers

Report by the Industrial Injuries Advisory Council in accordance with Section 171 of the Social Security Administration Act 1992 considering prescription for osteoarthritis of the knee in carpet fitters and carpet and floor layers

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INDUSTRIAL INJURIES ADVISORY COUNCIL

Secretary of State for Work and Pensions

Dear Secretary of State,

REVIEW OF OSTEOARTHRITIS OF THE KNEE IN CARPET FITTERS AND CARPET AND FLOOR LAYERS

We present our report which considers prescription for osteoarthritis (OA) of the knee in construction workers, including carpet fitters and carpet and floor layers. OA of the knee is a common disorder in the general population and was last reviewed with respect to coal miners in our Command paper published in August 2008 (Cm. 7440). Prescription for OA of the knee in coal miners relied on a combination of limited but high quality direct evidence of a greater than doubled risk of miner's developing the disease and a large amount of indirect evidence of a greater than doubled risk of OA of the knee in those undertaking substantial kneeling and squatting under heavy load, activities commonly undertaken by miners. In this review we have considered whether there are any occupations in the construction industry, including carpet fitters and carpet and floor layers where direct and/or indirect evidence exists of an excess risk of OA of the knee and where a case can be made for recommending prescription.

During the course of the review we have undertaken a detailed literature search, consulted with experts and trade union officials, and made a public call for evidence. We have concluded that the evidence in carpet fitters or carpet and floor layers is sufficient to recommend that OA of the knee be added to the list of prescribed diseases for those who have worked in these occupations for at least 20 years in aggregate.

There is insufficient evidence (direct or indirect), however, to support prescription of OA of the knee in other groups of construction workers. IIAC will keep this matter under review.

Yours sincerely,

Professor K Palmer

Chairman

23 November 2010

Summary

1. Osteoarthritis (OA) of the knee is a common disease in the general population, especially at older ages. The disease is characterised by destruction of the cartilage surrounding the knee joints and various alterations to the bone and the joint space between bones. The main symptoms include knee pain, knee swelling, stiffness and reduced mobility. OA of the knee can be a significant cause of disability, sufficient in advanced cases to require surgical knee joint replacement.

2. This review sets out the case for prescription for OA of the knee in construction trades, including carpet fitters and carpet and floor layers. The report follows the addition of OA of the knee to the list of prescribed diseases (PD) for coal miners (PD A14), and a subsequent scoping exercise in other occupations involving significant knee straining activity. During the course of review we have undertaken a detailed literature search, consulted with experts and trade union officials, and made a public call for evidence.

3. As explained in subsequent paragraphs, the case for prescription is typically built on direct research evidence that the risks of a particular disease in a particular occupation are more than doubled, relative to suitable comparators, under well defined and verifiable circumstances of exposure. In the case of PD A14, however, limited high quality direct research evidence in miners was bolstered by substantial and convincing indirect evidence of a greater than doubled risk of OA of the knee in those undertaking substantial kneeling and squatting under heavy load, activities commonly undertaken by miners (Cm. 7440). The present review considered both the direct research evidence on knee OA in construction workers, and the scope for combining direct and indirect research evidence in an analogous fashion.

4. In the event, ample direct evidence was found that the risk of OA of the knee is more than doubled in those working for at least 20 years in aggregate as carpet fitters or carpet and floor layers. The case for recommending prescription can thus be established without recourse to indirect evidence, consistent and supportive though this is.

5. By contrast, our review suggests that direct evidence of risk of knee OA in other construction trades is sparse and far from compelling. In particular, we found insufficient evidence in painters or carpenters, and only a few research reports suggesting an association between OA of the knee and construction work when defined in a general way. In this last case, risks are likely to vary by occupational sub-group among a wide and diverse workforce, and it did not prove possible to identify any specific occupations at high risk. Given a lack of high quality direct evidence on risks of knee OA in other construction workers, the case for prescription is weak and would be unduly reliant on extrapolation from sources of indirect evidence.

6. Accordingly, the Industrial Injuries Advisory Council (IIAC) recommends that OA of the knee be prescribed in relation to work wholly or mainly as a carpet fitter or carpet and floor layer for 20 years or more in aggregate. For the purposes of the Industrial Injuries Disablement Benefit (IIDB) scheme a diagnosis of OA of the knee should be based on knee pain, swelling, stiffness and restricted movement and, if possible, X-ray evidence of Stage 3-4 on the Kellgren-Lawrence scale, but should also be accepted in those who are on a surgical waiting list for knee replacement or have had a knee replacement previously.

7. IIAC does not recommend prescription for any other group of construction workers, but will continue to monitor emerging evidence. The Council encourages further research to widen the evidence base on which future recommendations on prescription can be framed.

This report contains some technical terms, the meanings of which are explained in a concluding glossary.

Introduction to the review

8. IIAC published its review of OA of the knee in coal miners in August 2008 (Cm. 7440), resulting in prescription for this condition (PD A14). In deciding that OA of the knee met the requirements for prescription, IIAC drew upon some direct evidence that there was an excess risk of the condition in miners and a plethora of indirect evidence of a significant association with the disorder and kneeling and squatting under heavy load (activities which miners would have undertaken). Following the review, IIAC has considered whether there are other occupations where sufficient direct evidence of a link between OA of the knee and the particular work in question exists, or where a combination of direct evidence, together with indirect evidence on risk-conferring exposures, makes a persuasive case for prescription. A preliminary scoping exercise, based on the weight of published scientific reports, suggested the need to focus on trades in the construction industry.

The Industrial Injuries Disablement Benefit Scheme

9. IIAC is an independent scientific statutory body set up in 1946 to advise the Secretary of State for Work and Pensions in Great Britain and the Department for Social Development in Northern Ireland on matters relating to the Industrial Injuries Scheme. The major part of the Council's time is spent considering whether the list of prescribed diseases for which benefit may be paid should be enlarged or amended.

10. The IIDB Scheme provides a benefit that can be paid where an individual has developed a 'prescribed' disease or sustained an occupational accident out of the course of their employment as an employed earner. In respect of accidents, the provisions cover not only the immediate, short-term disabling effects of the occupational injury, but also those that may develop many years after the original accidents. Identifiable incidents leading to OA of the knee may be accepted under the accident provisions of the Scheme. This report, however, concerns the potential to recognise OA of the knee as a prescribed disease in the absence of an identifiable accident.

The legal requirements for prescription

11. The Social Security Contributions and Benefits Act 1992 states that the Secretary of State may prescribe a disease where he is satisfied that the disease:

a) ought to be treated, having regard to its causes and incidence and any other relevant considerations, as a risk of the occupation and not as a risk common to all persons; and

b) is such that, in the absence of special circumstances, the attribution of particular cases to the nature of the employment can be established or presumed with reasonable certainty.

12. In other words, a disease may only be prescribed if there is a recognised risk to workers in an occupation, and the link between disease and occupation can be established or reasonably presumed in individual cases.

13. In seeking to address the question of prescription for any particular condition, the Council first looks for a workable definition of the disease. It then searches for a practical way to demonstrate in the individual case that the disease can be attributed to occupational exposure with reasonable confidence. For this purpose, reasonable confidence is interpreted as being based on the balance of probabilities according to available scientific evidence.

14. Within the legal requirements of prescription it may be possible to ascribe a disease to a particular occupational exposure in two ways – from specific clinical features of the disease or from epidemiological evidence that the risk of disease is at least doubled by the relevant occupational exposure.

Clinical features

15. For some diseases attribution to occupation may be possible from specific clinical features of the individual case. For example, the proof that an individual's dermatitis is caused by his/her occupation may lie in its improvement when s/he is on holiday, and regression when they return to work, and in the demonstration that they are allergic to a specific substance with which they come into contact only at work. It can be that the disease only occurs as a result of an occupational hazard (e.g. coal workers' pneumoconiosis).

Doubling of risk

16. Other diseases are not uniquely occupational, and when occupational factors contribute to causation, are indistinguishable from the same disease occurring in someone who has not been exposed to a hazard at work. In these circumstances, attribution to occupation on the balance of probabilities depends on epidemiological evidence that work in the prescribed job, or with the prescribed occupational exposure, increases the risk of developing the disease by a factor of two or more.

17. The requirement for, at least, a doubling of risk follows from the fact that if a hazardous exposure doubles risk, for every 50 cases that would normally occur in an unexposed population, an additional 50 would be expected if the population were exposed to the hazard. Thus, out of every 100 cases that occurred in an exposed population, 50 would do so only as a consequence of their exposure while the other 50 would have been expected to develop the disease, even in the absence of the exposure. Therefore, for any individual case occurring in the exposed population, there would be a 50% chance that the disease resulted from exposure to the hazard, and a 50% chance that it would have occurred even without the exposure. Below the threshold of a doubling of risk only a minority of cases in an exposed population would be caused by the hazard and individual cases therefore could not be attributed to exposure on the balance of probabilities; above it, they may be.

18. The epidemiological evidence required should ideally be drawn from several independent studies, and be sufficiently robust that further research at a later date would be unlikely to overturn it.

19. OA of the knee has several non-occupational causes and does not have unique clinical features, such that occupationally related cases can be reliably distinguished. The case for prescription, therefore, rests on reliable evidence of a doubling or more of risk – in this inquiry in construction workers – after allowance for other non-occupational risk factors.

20. In its earlier report (Cm. 7440), the Council found evidence that regular occupational kneeling and/or squatting, when allied with heavy lifting, could more than double the risks of knee OA. This evidence was used to strengthen the case for prescription in an occupation with reasonable, but limited, direct evidence of a doubling of risk (coal mining).

Method of investigation

21. The aim in the present inquiry was to identify construction trades for which direct evidence of a more than doubling of risk of knee OA was compelling enough to support prescription. Additionally, the Council explored whether, if only limited direct evidence could be found, a persuasive case could be made by considering the indirect evidence on risk of knee OA by physical activities common in the construction industry, in line with the approach outlined in paragraph 20.

22. The Council performed a detailed literature review covering published research on knee OA and physical activities in construction trades. The construction industry includes a wide range of individual occupations: to ensure a comprehensive search and to ascertain findings in the finest level of detail available, a master list of job titles was first established based on information supplied by the Health and Safety Executive (HSE) and from

the Construction Skills Network (Labour Market Intelligence 2009-2013 Report). The search on risks of knee OA was supplemented by a report on musculoskeletal problems in bricklayers, carpenters and plasterers commissioned for the HSE and selective consultation with experts in the field. A separate search on physical exposures in construction was supplemented by consulting an ergonomist from the HSE (Dr Simon Monnington), and relevant trades unions. The Council also issued a general call for evidence in the medical and scientific press. A list of those supplying evidence appears in Appendix 1.

Anatomy of the knee

23. The knee joint is a complex joint, formed where the end of the thigh bone (femur) and the top of the leg bone (tibia) meet, and is covered at the front by the knee cap (patella). The knee joint is the largest synovial joint in the body (the synovium is the tissue lining the joint that produces fluid to lubricate and protect the joint surfaces).

24. The joint is cushioned by articular cartilage. In addition, the menisci (discs of fibro-cartilage) are interposed between the tibia and the condyles of the femur, helping to increase the area across which load is transmitted through the joint. Ligaments connect the femur and tibia, and tendons, attach the muscle to the bones, stabilising and supporting the knee. A diagram of the knee joint can be seen in Figure 1.

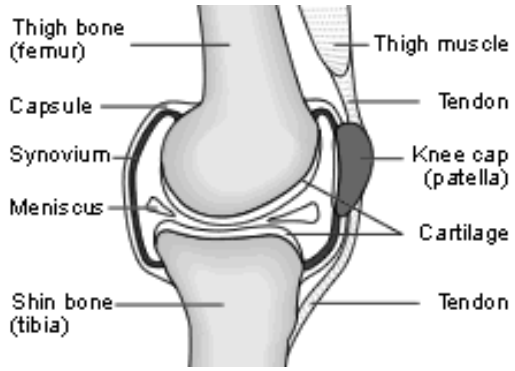

Figure 1. A normal knee joint (side view).

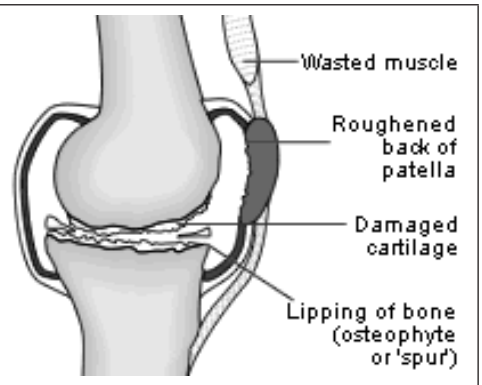

Figure 2. A knee joint with osteoarthritis.

Figure 1. Diagram of a normal knee joint. Figure 2. Diagram of an osteoarthritic joint. Diagram reproduced with kind permission from Arthritis Research UK.

Osteoarthritis of the knee

25. OA of the knee is a sequence of degradation and destruction of the cartilage surrounding the joints, resulting in exposure of the underlying bone, bone thickening, new bone regeneration, reduction of the bone space and altered biomechanics. A diagram of an osteoarthritic knee joint can be seen in Figure 2. In practice, two pairs of adjacent knee joint surfaces may be affected – those between the femur and the tibia (tibio-femoral OA) and those between the knee cap and the femur (patello-femoral OA). The diagnosis of knee OA is supported in individuals with knee pain, swelling, stiffness and limited mobility of the joint and pathological changes on radiographs, such as joint space narrowing, new bone formation and bone thickening. Such changes may be accelerated where the shock-absorbing cartilages of the knee are worn, torn or injured.

26. The radiological and clinical features of OA of the knee do not always correlate well. In the American National Health and Nutrition Examination Survey-I (NHANES-I) study, half of those with OA of the knee confirmed by radiograph did not experience pain. Knee pain is also common in the absence of OA, such that only 15% of those with knee pain in NHANES-1 had radiological evidence of OA pathology.

27. Treatment options include analgesic and anti-inflammatory medication, physiotherapy, functional aids and surgery. Severe OA of the knee may warrant total knee replacement.

Risk factors for osteoarthritis of the knee

28. A major risk factor for OA of the knee is increased age; most people will have some symptoms of OA by the time they are aged 70 years. Several other factors have been implicated in the development of OA of the knee: heredity predisposition, female sex, being obese, a previous knee injury or a meniscectomy (surgery to remove or repair a tear of the knee cartilage) and OA in other joints.

Consideration of the evidence

29. The Council's literature review identified 13 potentially relevant research investigations on disease and symptom risk, including (with overlap) eight reports in floor layers, six in builders, labourers, and construction workers, four in painters, four in carpenters and isolated reports in other trades. In some studies other construction occupations served as less exposed controls. For ease of description each of the studies and their findings is set out below. Additionally, the Council identified a limited number of reports on physical load in construction trades – also mentioned where relevant.

Knee osteoarthritis – cross sectional studies

30. Cross-sectional studies compare groups at a given point in time. One potential limitation in occupational studies is that affected workers may leave the occupations that cause them problems – in this context, perhaps, moving from physically demanding jobs to lighter work. If so, the prevalence of OA could be lowered in the risk-conferring occupation and relative risks (RR) thereby underestimated. This effect is sometimes referred to as survival bias or a healthy worker effect, as the healthy workers tend to 'survive' and be left behind. The cross-sectional data need to be read with this caveat in mind.

31. Wickstrom et al (1983) assessed physical workload, clinical symptoms and knee radiographs in 252 Finnish male concrete reinforcement workers and 231 male painters. X-rays were read by two radiologists who were unaware of (blinded to) workers' occupations, and work postures and lifting were systematically recorded by an engineer and a physiotherapist. Reinforcement workers were observed to stand with bent knees more often than painters (3% vs. 0%), to squat less (2% vs. 9%), and to lift loads of >20 kg more often (6 times/hour vs. rarely). However, both groups had a similar frequency of OA-related changes, such as osteophytes and joint space narrowing, on their knee radiographs.

32. Lindberg (1987) investigated radiographic OA by job title in a cross-sectional survey of older labourers from Malmo, Sweden, comparing rates with white-collar workers and men from the general population. Subjects were classified by their longest held job up to interview. About 1 in 5 of each group had had knee X-rays because of knee pain. Knee OA was found in 3.9% of labourers (based on 13 subjects) as compared to 1.4% to 1.6% in the other groups (Prevalence Ratio (PR) $\geq$2.4). The labourers had worked for an average of 32 years.

33. This study was limited methodologically, as radiographs were not obtained systematically, and ultimately on only a few subjects. The findings are compatible, however, with the possibility that heavy physical work in construction may double risks of knee OA.

34. Thun et al (1987) compared 112 floor layers aged 25-74 years from Cincinnati, Ohio with 285 blue-collar mixed controls. The RR of self-reported arthritis was barely elevated (RR 1.1, 95% Confidence Interval (CI) 0.7-1.8). However, this study did not employ a very specific measure of OA. A subset of 108 workers (19% of those approached) also underwent X-ray examination, from which it was concluded that the questions employed would identify fewer than half of radiographic cases.

35. Kivimaki et al (1992) obtained knee radiographs on 168 male carpet and floor layers aged 25-49 years from Southern Finland, comparing them with 146 similarly aged male painters. A job analysis was undertaken, based on videotapes and direct observations in a sample of workers, and this indicated that the carpet and floor layers had one or both knees on the floor for more than 40% of their working day, while such exposure was uncommon among the painters. Knee OA was defined radiographically by the presence of osteophytes on joint margins, with all radiographs read independently by two physicians who were blinded to workers' occupations. Clinical examinations were also performed, although the workers' occupations could not be disguised from the medical examiner.

36. Knee osteophytes were present in 58% of carpet layers and 41% of painters (PR 1.4). Some 2% of each group had arthritis as judged by the physician's clinical assessment. Carpet and floor layers, however, had more physician-diagnosed ruptures of their knee cartilage (10% vs. 5%), knee ligament lesions (6% vs. 3%) and bursitis in front of the knee (19% vs. 2%). This study involved only a crude comparison between groups with no account taken of differences in non-occupational risk factors such as body weight or past history of knee injury, and the criteria for diagnosing OA knee focussed on clinically less important degrees of disease. Narrowing of joint space, which was considerably less common overall (1-2%), was not analysed by occupation.

37. Jensen et al (2000) focussed on radiographic OA corresponding to grades 2 to 4 on the Kellgren-Lawrence scale (Appendix 2). These authors compared 50 Danish floor layers with 51 carpenters and 49 compositors aged 26-72 years, drawn from a larger cohort assembled in the Copenhagen area in 1994-5. Radiographs were independently assessed by two radiologists who were blinded with respect to subjects' history of knee complaints, trade and age. Floor layers were found to be at highest risk (14% vs. 8% in carpenters and 6% in compositors). For subjects aged over 50 years, the prevalence of radiographic knee OA with knee complaints during the past 12 months was 29% (95% CI 17-44%) among the floor layers as compared with 9% (95% CI 1-26%) in the carpenters and 1% (95% CI 1-10%) in the compositors. No account was taken of concurrent non-occupational risk factors, other than a crude allowance for age.

38. The job tasks arising among floor layers in this cohort were characterised in a later report as: installing linoleum (55% of workers), carpet (56%) and vinyl floorings (92%), as well as the removal of old flooring, grinding, filling, installing underlay, measuring and cutting materials, gluing and installing skirting board (but rarely laying parquet floors or wood on joists). Activities were full-time and not shared with other general construction duties. Table 1 compares the video record with workers' own estimates of the time spent in the different kinds of work. Knee-straining work represented some two thirds of the total work time, however estimated.

Table 1: Exposure assessment of knee straining work using video recordings and self reports of knee straining work activity (adapted from Jensen et al, Applied Ergonomics 2010; 41: 319-325 with kind permission).

		Knee straining work (% of total time)	
	No of subjects	Video recorded Mean	Self reported Mean
Installing linoleum	4	47	48
Installing carpets	2	56	40
Installing vinyl	2	92	95
Installing tiles	3	87	93
Installing underlay	2	81	82
Installing skirting board	3	86	94
Filling	3	45	70
Grinding	3	84	100
Cutting	2	30	50
Other work tasks	5	55	65
Overall	35	64.8	67.7

39. This investigation was subsequently enlarged (Jensen 2005), focussing on 133 floor layers, 506 carpenters and 327 compositors from the original cohort (including the subjects from Jensen (2000)). Subjects were asked about knee complaints, non-occupational risk factors for knee OA and self-reported time spent in work tasks and in the trade. Work tasks were then video-recorded among the floor layers and carpenters, and an index of video-recorded knee strain constructed. Lifetime exposure to kneeling and squatting ('knee-strain exposure index') was quantified as the product of the video estimate and the duration of their work history. Radiological examinations were carried out on a sample of 150 subjects, chosen to include some workers with knee pain and some without. This time statistical analysis allowed for age, body mass index, smoking, and knee-straining sports activities. Those with previous acute knee trauma were excluded.

40. Odds Radios (ORs) for self-reported knee complaints and radiographically determined knee OA, in comparison with the reference group of compositors, rose in a pattern related to the degree of knee-straining work demands. Thus, the OR for OA rose from 3.0 (95% CI 0.5-17.2) in those with a low to moderate exposure index score to 4.9 (95% CI 1.1-21.9) in those with a very high score.

41. In a third investigation by the same research group (Rytter et al, 2009), 231 floor layers and 258 graphic designers were invited to participate in a clinical,

ultrasonographic and radiographic knee examination, after the exclusion of subjects with earlier knee injury. The final sample comprised 134 floor layers from Copenhagen and Jutland and 120 graphic designers from Copenhagen, including 24 floor layers and 23 graphic designers from the 1994-5 cohort who featured in the two earlier studies. Weight-bearing radiographs in three views were classified according to the degree of joint space narrowing with findings reported separately for different compartments of the knee. Analysis allowed for age, body mass index and knee-straining sporting hobbies.

42. The prevalence of tibio-femoral OA rose with years of trade seniority in both occupations, but more steeply among the floor layers. For example, in comparison with workers employed for ≤20 years, the OR in those employed 21-30 years was 2.3 in the floor layers but 1.4 in the graphic designers; and for those employed ≥31 years the corresponding ORs were 5.0 and 1.6 (relatively, a tripling of risk in the floor layers). In an analysis which compared the groups by age, there were no important differences in prevalence of tibio-femoral OA below age 50 years (OR, floor layers vs. graphic designers 1.1); but among those aged 50–59 years, risks were significantly elevated among the floor layers (OR 3.6, 95% CI 1.1–12.0); and almost doubled at age ≥60 years, although based on smaller numbers (OR 1.9, 95% CI 0.4-7.8). By contrast, there were no significant differences in prevalence of patello-femoral OA between the two occupational groups.

43. Owing to differences in the format of radiographs from different medical centres, blinding to occupation could only be achieved fully for workers from Copenhagen; but results in this subgroup were similar to those overall.

44. The authors concluded that floor laying carries a risk for tibio-femoral OA but not for patello-femoral OA, and suggested that any apparent lessening of effects in the oldest age group may have reflected survival bias (especially the tendency of older affected workers to quit their jobs) or response bias (participation rates were much lower among floor layers at age ≥60 years than at 50-59 years).

Knee osteoarthritis – Case-control studies

45. In case-control studies, cases of a disease (in this case OA of the knee) are compared with controls (people without knee OA) in terms of their past work histories and employment. A ready source of cases is patients being treated for their disease or being pensioned for it, so that in practice cases are often defined operationally by their treatment or award status (e.g. awaiting knee joint replacement or receiving a disability pension for OA; in these examples controls need not be OA-free, but cannot be upon a surgical waiting list for OA or being pensioned for it). One potential limitation is that the factors that influence access to treatment or compensation for a disease may be different

from the factors that influence its development. The case-control data need to be read with this caveat in mind, as do the later registry-based reports based on hospital care.

46. Vingard et al (1992) conducted a nested case-control study of men born in 1915-1934 in Stockholm County. 1,307 men who received a disability pension during 1979-81 and 1984 for disorders of the back, neck-shoulder, hip or knee were compared with 298 randomly selected men from the general population. RRs of disability pension for OA of the knee following at least 10 years employment in an occupation were estimated (vs. never being employed in 20 of the most exposed knee-straining jobs), and were particularly elevated in painters and carpet layers (RR 23.1, 95% CI 3.0-178.3), construction workers (RR 5.1, 95% CI 2.6-10.0), and metal workers (RR 3.2, 95% CI 1.7-5.9). The high RRs for disability pensioning in the group labelled "painters and carpet layers" is noteworthy, as is that in construction workers. However, data were not presented separately for painters and carpet layers.

47. Sandmark et al (2000) conducted a hospital-based case-control study in 14 counties of Sweden. Cases (patients undergoing joint replacement for tibiofemoral OA) and controls, selected at random from a central population register, were compared from the viewpoint of occupational physical activities and also by a simple comparison of job titles, with details established through a telephone interview. Among men, the OR for working in construction at the time of the interview was 3.1 (95% CI 1.5 - 6.4).

48. Holmberg et al (2004) conducted a population-based case-control study of knee OA in Sweden. Cases were defined as having radiographically confirmed severe or moderate tibio-femoral OA or a past history of osteotomy or prosthesis (surgical resection of bone or joint replacement), and were identified from radiology records in participating hospitals. Controls were selected from the general population and were matched by age, sex and county. Job titles were identified by means of self-completed postal questionnaires. Among builders the OR was significantly elevated after 11-30 years of employment (3.7, 95% CI 1.2 - 11.3), but less than doubled for lesser or greater periods of employment (1-10 yrs, OR 1.5; >30 years, OR 1.6). The non-linear relation with reducing risks at the longest durations of employment could reflect selection out of work by early retirement and therefore a healthy survivor bias.

Knee osteoarthritis – Record linkage cohort studies

49. Vingard et al (1991) conducted a prospective cohort study of 35-75 year-olds from Sweden in 1981-3. A comparison was made of hospital admission rates by occupation in construction trades and a panel of other blue-collar jobs deemed to involve low physical work effort. Linkage was achieved between subjects' hospital discharge records for knee OA and their occupational titles

at the national censuses of 1960 and 1970. In contrast to some other reports, risks were only slightly elevated in male construction workers (RR 1.36, 95% CI 1.13-1.79).

50. Jarvholm et al (2008) compared hospitalisation rates for surgically treated OA of the knee in a large cohort of male Swedish construction workers aged 15-67 years, identified through an occupational health programme. A registry-based comparison was made with a baseline of various white-collar jobs. Table 2 is an extract of the main findings. The elevated risks in floor layers are particularly noteworthy.

51. Jarvholm et al ascribed this high rate of OA of the knee in floor layers to "occupational kneeling and creeping", rather than squatting (which was similarly low among floor layers and painters in the study referred to in paragraph 35). They considered that heavy workload while kneeling was also important and contributed to the higher rates in concrete workers, bricklayers and woodworkers – in contrast to electricians who knelt but did not move or lift heavy loads. The findings in asphalt workers were unexpected and have not been replicated so far elsewhere.

Table 2: Relative risk (RR) of surgical treatment for knee OA in Swedish construction workers (vs. white collar occupations). Adapted from Jarvholm et al, Occup Environ Med 2008; 65: 275-8 with kind permission.

Occupation	**RR**	**(95% CI)**
Asphalt workers	2.81	(1.11-7.13)
Bricklayers	2.14	(1.08-4.25)
Floor layers	4.72	(1.80-12.33)
Plumbers	2.29	(1.19-4.43)
Rock workers	2.59	(1.18-5.69)
Sheet metal workers	2.60	(1.06-6.37)
Woodworkers	2.02	(1.11-3.69)
Drivers	2.01	(0.89-4.53)
Concrete workers	1.80	(1.00-3.25)
Electricians	1.18	(0.53-2.59)
Painters	1.44	(0.70-2.95)

Knee cartilage injury

52. Rytter et al (2009b) performed Magnetic Resonance Imaging (MRI) scans on the knees of 92 male floor layers and 49 male graphic designers (referents), with a mean age of 55.6 years, who also participated in the radiological examination study reported in paragraph 41. Degenerative tears were significantly more prevalent in the medial meniscus (cartilage) among floor layers (OR 2.28, 95% CI 1.10–4.98) and significantly more floor layers had tears in the medial menisci of both knees (OR 3.46, 95% CI 1.41–8.48).

Knee pain

53. O'Reilly et al (2000) conducted a postal survey of 4,057 men and women age 40-80 years registered with two general practices in Nottingham (one located in a coal mining community, the other in the city). Self-reported chronic knee pain – defined as pain in or around the knee on most days for at least a month, also present during the past year – was more common in construction workers (OR 2.4, 95% CI 1.4-4.1) and carpenters (OR 4.6, 95% CI 1.9-11.1) than in other occupations.

Kneeling and squatting in the construction industry

54. Some observations on kneeling and/or squatting in construction trades are contained in the reports by Wickstrom et al (paragraph 31), Kivimaki et al (paragraph 35) and Jensen et al, 2000 (paragraph 37); but information is piecemeal and relatively scanty. The Danish data suggest that knee-straining activity occupies a large proportion of total work time in carpet and floor layers (around 65% – Table 1); and a later report by the same research group (Jensen et al, 2010), based on continuous video observations of four floor layers outwith the original group, reached a similar estimate (41% to 53%). Kivimaki's data also suggest that kneeling is common in floor and carpet layers (42% of working time), but far less common in painters (5% or less), and that squatting represents only 3% of work time, with a similar frequency in these two groups. The report by Wickstrom et al points to a somewhat higher level of squatting in painters (9% of work time), with comparative information only for concrete reinforcement workers.

55. Separately, Hartmann et al (2005) conducted an observational study on 340 German construction workers. As well as identifying some trades involving overhead reaching, lifting, or a bent posture, it was estimated that painters spent about 24% of their regular daily work time in kneeling postures, the corresponding figures for plumbers and carpenters being 17% and 7% respectively. No data were supplied on floor or carpet layers.

56. An HSE ergonomist, Dr Simon Monnington, identified floorers, carpet layers, tilers, plumbers, electricians and roofers as trades likely to undertake frequent kneeling at work, but quantitative estimates of exposure were not available at the time of inquiry.

Summary of the evidence

57. The evidence base on knee OA is strongest for floor and carpet layers, and comprises studies from the US (Thun et al, 1987), Finland (Kivimaki et al, 1992), Denmark (Jensen et al, 2000; Jensen et al, 2005; Rytter et al, 2009) and Sweden (Vingard et al, 1992; Jarvholm et al, 2008), encompassing a range of study designs (cross-sectional, case-control and registry-linked cohort studies). Although there was overlap in the subjects studied in the reports from Denmark, the study by Rytter et al (paragraph 52) comprised many new subjects relative to that by Jensen et al, 2005 (paragraph 39).

58. The methodologically weaker early studies from the US and Finland found only a moderate elevation in risk. But the three cross-sectional reports from Denmark (all of which considered only subjects with no prior knee injury) suggest a more than doubling of risk among older workers with a long employment history, with evidence supporting a dose-response relationship. The studies from Sweden found a markedly higher rate of disability pensioning (23-fold) and a 4.7-fold increased risk of surgical treatment in hospital. A more than doubled risk of cartilage tears was also found among the Danish floor layers (Rytter et al, 2009b).

59. The studies from Denmark suggest that risks are not increased below age 50 years and risks were only demonstrably doubled after more than 20 years of work experience (although this outcome was influenced by investigator choices and the material at hand, and does not disprove a doubling of risk over a shorter interval). The two Swedish reports on OA provide no indication of the likely exposure duration among affected floor layers, and further inquiries of the authors yielded no additional data on risks over shorter exposure times.

60. The hygiene data on carpet and floor layers confirm their high and sustained daily exposure to occupational kneeling (Jensen et al, 2000; Kivimaki et al 1992; Jensen et al, 2010). This is a risk factor for knee OA in the general population. Thus, for example, a British case-control study by Coggon et al (2000) compared 518 patients listed for surgical treatment of knee OA with controls from the same communities, matched for sex and age. After statistical allowance for body weight, history of knee injury and other factors, risks were more than doubled in subjects who reported kneeling or squatting at work for more than one hour per day over at least one year. In another study, of over 2000 older adults from a general practice in Bristol, Cooper et al (1994) selected people with pain around the knee on most days for at least a month in the past year, and an equal number of pain-negative controls, to undergo X-ray examination of the knee. Subjects were classified according to the activities in their longest held job prior to the onset of symptoms (cases) or interview (controls). After adjustment for other risk factors, the OR for knee OA was 2.5 for those whose jobs entailed considerable kneeling or squatting. In the first US NHANES-I, a general population survey of over 5,000 subjects, repeated knee bending was associated with ORs elevated 2.4 to 3.1-fold at ages 55-64 years (Anderson et al, 1988).

61. Collectively, the evidence is sufficient to make a case for prescription in carpet fitters and carpet or floor layers who have worked full time under exposure circumstances such as those defined in paragraph 38 for a period of 20 years or more in aggregate.

62. The Council found considerably less evidence in relation to other occupations. Carpenters were treated as a control group in two of the Danish studies (Jensen et al, 2000; Jensen et al, 2005) and had a substantially lower prevalence of knee OA than floor and carpet layers. Risks of knee OA among woodworkers were more than doubled in the study by Jarvholm et al (Table 2), and those of chronic knee pain increased more than four-fold in the community survey by O'Reilly et al (paragraph 53); but no other evidence was found on risks of OA in this occupation. The case for prescription for carpenters is not considered sufficient, given the current balance of evidence.

63. Painters were treated as a control group in the study by Kivimaki (1992) and were found to have less evidence of OA (paragraph 35). They were also regarded as controls in the study by Wickstrom et al (paragraph 31) and found to have a similar rate of knee OA to workers with a heavier physical workload. They were found only to have a moderate elevation of risk (RR 1.44) in the study by Jarvholm et al (Table 2). Finally, risks of disability pensioning in the study by Vingard were much elevated, but in an analysis which also included and did not distinguish floor layers (paragraph 46). The case for prescription for painters is not considered sufficient, given the current balance of evidence.

64. Several studies reported on risk of knee OA in builders (Holmberg et al, 2004), labourers (Lindberg, 1987) and construction workers (Vingard et al, 1991; Vingard et al, 1992; Sandmark et al, 2004). With the exception of the cohort study of hospital admissions by Vingard (paragraph 49), all RRs exceeded two. Unfortunately these job titles cover a multiplicity of trades, some perhaps conferring a doubling of risk of knee OA, but others certainly not. The Council feels unable to recommend prescription for builders, labourers or construction workers as a class, without more evidence as to the occupation(s), level(s) and type(s) of risk-conferring activity.

65. The study by Jarvholm et al identifies a number of other occupations potentially at increased risk of knee OA, such as plumbers, asphalt, rock and sheet metal workers (Table 2); but the findings have not been corroborated so far in other reports.

66. The Council has explored the case for combining indirect evidence on risk of knee OA by physical activity with direct evidence on risk by occupational title. However, only limited evidence was received on jobs within the construction industry that could be characterised by knee-straining physical activity. More fundamental from the viewpoint of prescription is the lack of direct evidence on risks of knee OA by job title (other than for carpet fitters

and floor and carpet layers, among whom it is deemed sufficient). The Council has decided against extrapolation, in the absence of more convincing direct evidence of a doubling of risks.

Conclusions and recommendations

67. The Council recommends that OA of the knee should be prescribed in relation to work as a carpet fitter or as a carpet or floor layer for 20 years or more in aggregate. To be reckonable against the qualifying time limit, this service should represent the main activity.

68. In line with paragraph 38 of this report, the Council intends the work activities of qualifying claimants to include some or all of the following: installing linoleum, carpet or vinyl floorings; removal of old flooring; installing of underlay; installing of skirting board; and the associated preparatory work. Having taken additional ergonomic advice from the HSE, the Council considers that workers who lay parquet floors and wooden floors should also be covered by the terms of prescription, but not workers whose main activity is to lay concrete floors.

69. The Council proposes the following prescription schedule:

Prescribed disease	**Schedule**
Osteoarthritis of the knee	Work wholly or mainly as a carpet fitter or as a carpet layer or floor layer for a period of at least 20 years in aggregate

70. The diagnosis of OA of the knee for the purposes of the IIDB Scheme should be based on knee pain, swelling, stiffness and restricted movement and if possible X-ray evidence of Stage 3 to 4 on the Kellgren-Lawrence scale (Appendix 2); but should also be accepted in those who are on a surgical waiting list for knee replacement or have had a knee replacement previously.

71. The Council considers that, in claimants who fulfil the terms of paragraph 69, knee OA should be presumed as due to the nature of the work. Presumption should apply whether the disease is confined to one knee or affects both knees, and whether or not there is a previous history of knee injury.

72. The Council encourages future research on knee OA in construction workers. Ideally, from the viewpoint of prescription, this would distinguish risks more clearly by occupational title. Also, the Council would welcome evidence on whether the risks of knee OA in carpet and floor layers may be doubled over a shorter interval than set out in paragraph 69.

Prevention

73. Preventative measures fall into two main groups. The first is about eliminating the risk through redesign, examples of which are:

- Redesign of the carpet laying tasks, so that the work can be done standing. Research shows this does reduce knee pain, however its introduction required good collaboration between employers and workers (Jensen et al, 2008).

- Arrange the pathways and surfaces so that the risks of slipping, tripping falling will be reduced. HSE has been running a campaign “Shattered lives” on this topic for the last 2 years.

74. The second group of measures are about reducing exposure. This can be achieved through wearing personal protective equipment and the literature suggests the following three options could be considered, although their effectiveness in reducing the incidence of OA is unproven.

- *Knee pads* are useful for protection of the knee while kneeling on hard floor surfaces, but they do not mitigate the risks of extreme flexion of the knee. Their benefit is largely in respect of preventing lacerations and penetrating injuries and improving comfort. It is not known whether they reduce the risk of OA.

- *Limb support devices* can be an effective intervention against lower limb disorders in occupational workplaces or the aggravation of injury, particularly against knee injury. They provide support for the weight of the trunk and buttock/thigh during kneeling and prevent maximal flexion and load bearing at the knee(s).

- *Manual handling aids* can minimise lower limb injuries. But there is evidence that they may not be used. Also, the presence of wires and cables on the floor may make it impracticable.

Diversity and equality

75. IIAC is aware of issues of equality and diversity and seeks to promote them as part of its values. The Council has resolved to seek to avoid unjustified discrimination on equality grounds, including age, disability, gender reassignment, marriage and civil partnership, pregnancy and maternity, race, religion or belief, gender and sexual orientation. During the course of the review of OA of the knee in carpet fitters and carpet and floor layers or construction workers no diversity and equality issues were apparent.

Appendix 1: List of experts consulted

Dr Rolf Ellegast, Institute for Occupational Safety and Health of the German Social Accident Insuranc, Germany

Dr Eva Holmstrom, Lund University, Sweden

Professor Bengt Järvholm, Umeä University, Sweden

Dr Lilli Kirkeskov Jensen, Regional Hospital Skive, Denmark

Professor Eva Vingård, Uppsala University, Sweden

Dr Simon Monnington, Health and Safety Executive

Appendix 2: Kellgren-Lawrence scale

Grade	Comments
0	No radiographic findings of osteoarthritis
1	Minute osteophytes of doubtful clinical significance
2	Definite osteophytes with unimpaired joint space
3	Definite osteophytes with moderate joint space narrowing
4	Definite osteophytes with severe joint space narrowing and subchondral sclerosis

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Glossary of terms used in this report

Types of study

Case-control study: A study which compares people who have a given disease (cases) with people who do not (controls) in terms of exposure to one or more risk factors of interest. Have cases been exposed more than non-cases? The outcome is expressed as an **Odds Ratio**, a form of **Relative Risk**.

Cross-sectional study: A study which compares characteristics between groups at a given point in time. This type of study is generally used in calculating the prevalence of a characteristic or the **Prevalence Ratio** between groups. It tends not to give very strong evidence on causality.

Cohort study: A study which follows those with an exposure of interest (usually over a period of years), and compares their incidence of disease or mortality with a second group, who are unexposed or exposed at a lower level. Is the incidence rate higher in the exposed/more exposed workers than the unexposed/less exposed group? Sometimes the cohort is followed forwards in time ('prospective' cohort study), but sometimes the experience of the cohort is reconstructed from historic records ('retrospective' or 'historic' cohort study). The ratio of risk in the exposed relative to the unexposed can be expressed in various ways, such as a **Relative Risk**, **Risk Ratio**, **Rate Ratio** or **Standardised Mortality Ratio**.

Record linkage study: A study which links different data sets at the level of the individual; for example, one on exposure (occupation) and one on outcome (hospital admission for knee OA).

Nested case-control study: A form of **case-control study** in which the cases and controls all come from within a well-defined cohort. Controls are selected from subjects that are at risk at the time that new cases arise – in effect, a **cohort study** in which only some of the non-cases are sampled (for various legitimate reasons – e.g. lowering the costs of special investigations).

Measures of association

Statistical significance: This refers to the probability that a result as large as that observed, or more extreme still, could have arisen simply by chance. The smaller the probability, the less likely it is that the findings arise by chance and the more likely they are to be 'true'. A 'statistically significant' result is one for which the chance alone probability is suitably small, as judged by reference to a pre-defined cut-point. (Conventionally, this is often less than 5% ($P<0.05$)).

Relative Risk (RR): A measure of the strength of association between exposure and disease. RR is the ratio of the risk of disease in one group to that in another. Often the first group is exposed and the second unexposed or less exposed. *A value greater than 1.0 indicates a positive association between exposure and disease.* (This may be causal, or have other explanations, such as bias, chance or **confounding**.)

Odds Ratio (OR): A measure of the strength of association between exposure and disease. It is the odds of exposure in those with disease relative to the odds of exposure in those without disease, expressed as a ratio. For rare exposures, odds and risks are numerically very similar, so the OR can be thought of as a **Relative Risk**. *A value greater than 1.0 indicates a positive association between exposure and disease.* (This may be causal, or have other explanations, such as bias, chance or **confounding**.)

Prevalence Ratio: Prevalence is the proportion of cases at a given point in time among those at risk (expressed as a fraction or a percentage). Prevalence ratio is the ratio of the prevalence in a group with the exposure of interest relative to the prevalence in an unexposed group. It is a form of **Relative Risk**.

Other epidemiological terms

Confidence Interval (CI): The **Relative Risk** reported in a study is only an *estimate* of the true value in the underlying population; a different sample may give a somewhat different estimate. The CI defines a plausible range in which the true population value lies, given the extent of statistical uncertainty in the data. The commonly chosen 95%CIs give a range in which there is a 95% chance that the true value will be found (in the absence of bias and confounding). *Small studies generate much uncertainty and a wide confidence interval, whereas very large studies provide a narrower confidence interval of compatible values.*

Confounding: Arises when the association between exposure and disease is explained in whole or part by a third factor (confounder), itself a cause of the disease, that occurs to a different extent in the different exposure groups being compared.

For example, smoking is a cause of lung cancer and tends to be more common in blue-collar jobs. An apparent association between work in the job and lung cancer could arise because of differences in smoking habit, rather than a noxious work agent. Studies often try to mitigate the effects of ('control for') confounding in various ways such as: restriction (e.g. only studying smokers); matching (analyzing groups with similar smoking habits); stratification (considering the findings separately for smokers and non-smokers); and mathematical modelling (statistical adjustment).

Blinding: In the context of this report, blinding is a process in which the determination of an individual's outcome or health status is made without knowing their exposure history or occupation. *Blinding is aimed at minimising any inadvertent bias that could arise when an assessor has a certain prior expectation about exposure-disease relationships.* Likewise, blinding can also be applied to the assessment of exposure in the absence of knowledge about health outcome.

Other technical terms

Articular cartilage: Articular cartilage forms a layer on the lower end of the thigh (femur), upper end of the shin (tibia) and the under surface of the kneecap (patella) which allows the surfaces to move with very little friction.

Bursitis: Bursitis is inflammation of one or more of the bursae (small sacs) of synovial fluid in the body; for example, the bursa between the knee cap and femur may get inflamed by repeated trauma.

Condyles of the femur: At the lower end of the femur the bone has two bulbous lumps called the condyles that distribute the weight-bearing load on the knee joint.

Osteophytes: These are protrusions of bone and cartilage associated with a degenerating joint, commonly known as bone spurs.

Meniscus: The menisci of the knee joint (knee cartilages) are formed from two pads of cartilaginous tissue which serve to dissipate friction in the joint.

Meniscectomy: A meniscectomy is surgical removal of all or a part of a damaged or torn meniscus (cartilage).

Body Mass Index: A measure of a person's weight relative to height, used to assess whether an individual is overweight or obese.

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